BROMINE

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Bromine is a natural element widely found in nature, principally in seawater, salt lakes, and underground brines associated with oil. The quantity of bromine sold or used in the United States in 2002 was 222 million kilograms (Mkg) valued at $166 million (table 1). The average value of bromine sold or used was $0.75 per kilogram (table 1). Primary uses of bromine compounds were in flame retardants (40%), drilling fluids (24%), brominated pesticides (mostly methyl bromide) (12%), water-treatment chemicals (7%), and others (17%) (Chemical Market Reporter, 1999). Bromine production in descending order and percentage of total for 2002 was estimated to be as follows: the United States, 41%; Israel, 38%; China, 8%; the United Kingdom, 7%; and other countries, 7% (table 5). Because of depleting reserves, distribution and economics, environmental constraints, and the emergence of Israel as the world's second largest producer, the U.S. portion of world production has decreased steadily since 1973 when the United States produced 71% of the world supply.

Legislation and Government Programs

About 50 studies are now underway at the Centers for Disease Control & Prevention (CDC) toxicology branch to try to establish safe and unsafe levels of some chemicals. In future surveys, the CDC will analyze other additional chemicals, including polybrominated flame retardants. The CDC released the most extensive assessment ever made of the U.S. population's exposure to environmental chemicals. For the survey, the CDC measured 116 chemicals in blood and urine samples collected in 1999 and 2000 from people across the Nation. The first nationwide survey tested toxicity levels for only 27 chemicals. The new findings included expanded data on lead exposure in children, exposure to organophosphate pesticides, dioxins and dioxin-like chemicals, and other chemicals not connected to bromine. Eighty-nine of the chemicals had never been measured in the U.S. population (Hileman, 2003).

Methyl bromide was listed as a class I ozone-depleting substance in the 1990 Clean Air Act (CAA) and had been scheduled to be phased out in the United States by January 1, 2001. The U.S. Congress extended the phaseout of methyl bromide until January 1, 2005, to coincide with the deadline for developed countries under the Montreal Protocol on Substances that Deplete the Ozone Layer. Under the Clean Air Act Amendments of 1990 (CAAA) (Public Law 101-549), U.S. production and imports of bromine must be reduced from 1991 levels as follows: 25% by 1999; 50% by 2001; 70% by 2003; and a full ban by 2005. Domestically, methyl bromide had proven to be a difficult pesticide to replace because of its low cost and usefulness against a large variety of agricultural pests. The CAAA allowed for the exemption of critical uses of methyl bromide that have not yet been defined. The U.S. Environmental Protection Agency (EPA) held its third in a series of stakeholder meetings on the process on October 26, 2001, and will continue sector-based meetings. The EPA evaluated these applications based on technical and economic criteria and will develop with other agencies a nomination package that was submitted to the Secretariat of the Montreal Protocol in February 2003 (U.S. Environmental Protection Agency, 2003§[1]). The dominant use of methyl bromide was in soil treatments. It also was used in chemicals for termite treatment. Three producers—Albemarle Corp., Great Lakes Chemical Corp., and Israel's Dead Sea Bromine Co. Ltd. (DSB)—were the major manufacturers, accounting for 75% of global production. Under the Montreal Protocol, developing countries had until 2015 to phase out methyl bromide production.

Countries may request exemptions from phaseout requirements for uses where there are no feasible technical or economical alternatives. After a joint EPA-U.S. Department of Agriculture technical review, the United States made a formal request to the Ozone Secretariat of the United Nations to allow use of methyl bromide after the January 1, 2005, phaseout deadline. The exemption would allow methyl bromide consumption in 2005 at 39% of the total 1991 consumption level and in 2006 at 37% of the 1991 level. The exempted uses included food processing, commodity storage, and treatment of forest seedlings, tomatoes, peppers, egg plants, strawberries, and sweet potatoes. Australia, Canada, Greece, and Italy also planned to request exemptions (Chemical & Engineering News, 2003).

The U.S. Senate Foreign Relations Committee approved the amendments to the Montreal Protocol, which limits the production, trade, and use of chemicals linked to destruction of stratospheric ozone. The amendments approved by the committee were signed by the President of the United States in 1997 and 1999. The 1997 amendment would add methyl bromide to a list of substances that are subject to trade controls with countries that are not party to the Montreal Protocol. It would also add a licensing requirement for the export and import of all substances controlled under the treaty. The 1999 amendment would add bromochloromethane to the list of controlled chemicals, begin a phaseout of production and consumption of the substance, and establish a trade ban with nonparty countries (Chemical Market Reporter, 2002a).

In the interest of information exchange, a document by R.T. Wickham (2002§) entitled the "Status of Industry Efforts to Replace Halon Fire Extinguishing Agents" was disseminated under the sponsorship of the EPA. With the CAAA, the U.S. banned the

[1]References that include a section mark (§) are found in the Internet References Cited section.

production and import of virgin halons 1211, 1301, and 2402 beginning January 1, 1994. The fire protection industry accepted the challenge to find alternatives to halons and supported the early phaseout of halon production in 1994. The halons most frequently encountered in fire protection applications are bromine-containing compounds that are described as liquefied compressed gasses. For practical purposes, only two halons reached any commercial significance in the United States—halon 1301 ($CBrF_3$) and halon 1211 ($CBrClF_2$). Owners of halon 1301 systems have little incentive to remove and replace them with systems using halon alternatives as the alternatives are more expensive and less effective. With the exception of the U.S. Department of Defense, there has not been a significant concerted effort to remove halon 1301 systems from service. It is estimated at 75% of the halon 1301 agent used in North America was employed in the protection of essential electronics. Halon 1211 hand-portable extinguishers are in widespread use and prices make the recharging and use possible for years to come.

Bromine was taxed under the Comprehensive Environmental Response, Compensation, and Liability Act (Superfund) that had gone through two reauthorizations since its enactment in 1980. Congress allowed the Superfund taxes to expire at the end of 1995. At yearend, legislative attempts to reinstate the fund had not passed. The trust fund supported by the taxes is expected to decline to $28 million by the end of 2003 from a high of $3.6 billion in 1996 (Hess, 2003; Campaign to Clean up Toxics, undated§).

The U.S. Consumer Product Safety Commission (CPSC) in January 2002 denied the 1994 request of the National Association of the State Fire Marshals to adopt the existing California Bureau of Home Furnishings and Thermal Insulation standards for residential upholstered furniture or other suitable existing standards. A meeting was held June 18-19, 2002, for CPSC staff and interested members of the public to discuss options for addressing upholstered furniture flammability. Presentations at the meeting also covered recent industry activities, technical data, and innovations related to the small open flame performance of upholstered furniture. The CPSC staff was making revisions to its draft small open flame standard as a result of the comments presented at the meeting. The California standard was issued in 1975 and did not contain information on the health effects from exposure to chemical fabric treatments. CPSC staff began working with the EPA's Office of Pollution Prevention and Toxics to develop a "Significant New Use Rule" for fire retardant chemicals used in fabric treatments to meet a new flammability standard for upholstered furniture (U.S. Consumer Product Safety Commission, 2003§).

Production

Domestic production data for bromine were developed by the U.S. Geological Survey from a voluntary canvass of U.S. operations. Of the operations to which a canvass form was sent, six responded, representing 100% of total elemental bromine produced (table 1).

Albemarle Corp.'s bromine production came from three plantsites in southern Arkansas. Albemarle had 31 bromine production wells, 6 of which also produced oil. The temperature of the brine wells were twice as wide and twice as deep as typical Arkansas oil wells. The brine that was produced exceeded 110° C (230° F).

Great Lakes Chemical Corp. continued production of bromine from brines at three plants in Arkansas. The company also owned Associated Octel Co. Ltd. of the United Kingdom.

Calcium bromide, sodium bromide, and zinc bromide, collectively referred to as clear brine fluids (CBFs), were used in oil and gas applications. CBFs have high specific gravities and were used in completion and workover activities to reduce the likelihood of damage to the well bore and productive zone. TETRA Technologies, Inc. was one of the largest users of CBFs in the world. Calcium bromide and zinc bromide were purchased by TETRA from two domestic and one foreign manufacturer. TETRA also recycled calcium- and zinc-bromide CBFs repurchased from its oil and gas customers. Its West Memphis, AR, facility produced calcium bromide and zinc bromide from zinc-containing electroplating sludge and low-cost hydrobromic acid. TETRA began operation of an elemental-bromine, calcium-bromide, and sodium-bromide plant at Dow Chemical Co.'s Ludington, MI, facility in mid-1998, using purchased crude bromine from Dow's calcium-magnesium chemicals operation. The liquid sodium bromide was sold to the industrial water treatment markets. TETRA also owned a plant in Magnolia, AR, that was designed to produce calcium bromide but was not operational in 2002. Approximately 13,400 hectares (33,000 acres) of bromine-containing brine reserves in the vicinity of the plant were under lease (TETRA Technologies, Inc., 2002§, p. 4, 6, 11).

The Industrial Minerals Association, North America, held its inaugural meeting in Arlington, VA, in April. European industrial mineral producers have had a representative body since 1993, but a similar organization did not exist in North America. Membership had risen to 38 organizations by June. Mineral-specific breakout sessions identified a number of areas of concern that resulted in the creation of standing committees covering engineering, health and safety, government and environmental affairs, membership, operations, and transportation. The association provided companies with the opportunity to share expertise on common issues, such as landuse/permitting, mining, processing, and safety and health (Industrial Minerals, 2002).

Consumption

The value of the biocide market was estimated to be $2.4 billion in 2000, with growth between 3.5% and 5% during the past 3 years. Halogenated specialty biocides are the leading product category with 25% of the total market. Leading applications in North America are household, industrial, and institutional disinfectants and sanitizers, recreational water, and wood preservation. These applications account for nearly 80% of consumption volume and 50% of consumption value (Challener, 2001). North America was the largest market with 55%, followed by Western Europe with 25%; and the rest of the world with 20%.

Transportation

Albemarle announced on January 10, 2002, that it had contracted with Cendian Corp. to outsource its global transportation and logistics functions. The change was made to enhance Albemarle's effectiveness in the execution, planning, routing, and scheduling of shipments to its customers. Cendian was the leading solutions provider for the comprehensive management of shipping and logistics services for chemical companies (Albemarle Corp., 2002§).

World Review

European Union.—The European Parliament rejected broadening a ban on octabromodiphenyl ether and decabromodiphenyl ether under the European Commission's proposed electroscrap recycling directive. The Parliament agreed to delay a decision on the two brominated flame retardants until the completion of a full scientific risk assessment study. The European Parliament decided fire safety benefits and the lives saved and injuries prevented justified the decision. Substances banned by the directive are to be harmonized across Europe on January 1, 2006, which means that individual member-states will be unable to adopt earlier bans (European Chemical News, 2002).

India.—The Central Salt & Marine Chemicals Research Institute of India reported the fabrication and operation of pilot plants for the production of bromine, potassium chloride, and refractory-grade magnesia. The major research and development programs of the institute relate to desalination of brackish/saline water, ion exchange resins and polymers, marine algae, marine chemicals, reverse osmosis, salt and salt engineering, inorganic chemicals, photoionorganic chemistry, and phytosalinity (Central Salt & Marine Chemicals Research Institute, undated§).

Russia.—Astrakhan Oblast contains a gas condensate field discovered in 1976 for use by the Astrakhangazprom enterprise. The operating field is the largest in the Russian south and is unique for its reserves of gas and condensates. The depth of the field is 3,827 to 3,990 m. Iodine and bromine occur at depths of 100 to 200 m and 3,000 to 3,500 m, respectively. In 2002, gas, petroleum, and sulfur were produced. Production is planned as follows: iodine, up to 30 metric tons per year (t/yr) and bromine, up to 150 t/yr. An investment of $6 million is needed for the iodine and bromine project, and costs are expected to be recovered in 0.6 to 1.6 years (Russian Foreign Investment Promotion Center, undated§).

Current Research and Technology

Intec Ltd. based at Sydney University, Australia, emerged as the international leader in the development of chloride hydrometallurgical technology. The process uses chloride/bromide leaching, purification, and electrowinning for a cost-effective and environmentally responsible recovery of base and associated precious metals from sulfide ore bodies. The Intec process incurs lower capital and operating costs than alternative technologies while reducing the environmental impacts associated with conventional smelters (Wood and Allerton, 2002). High-quality copper metal is electrowon from a purified electrolyte of sodium chloride, sodium bromide, and copper ions of a diaphragm cell. Copper extraction was typically 98.5%. Gold was recovered using a carbon filter.

Technology developed at Sydney University was used on the Eunsan deposit in southwestern Chollanam-Do Province, Republic of Korea. The open pit stockpile consisted of about 26,000 metric tons of oxidized gold and silver ore grading approximately 13.2 grams per ton (g/t) gold and 600 g/t silver (Minesite.com, 2002§).

Bromine and cyanide beneficiation tests were performed by VTT Mineral Processes on the Osikomäki and Pirilä gold deposits in southeastern Finland. Leaching with cyanide and bromine recovered between 75% and 80% of gold from the ore depending on the grinding fineness (Endomines Oy, 1999§).

Michigan State University scientists demonstrated multiple reactivity by carrying out one-pot reactions with dibromobenzene to form a branched brominated polyphenylene. The principal factor that enables the one-pot transformation is the extremely high selectivity of the catalysts for carbon-hydrogen activation. The addition of halogens significantly increased the reaction rate. The process demonstrates that chemical feedstocks could be converted to common reagents with high product yields for use in the synthesis of pharmaceuticals and sophisticated organic materials (Ritter, 2002).

The National Cancer Institute, the National Institute for Environmental Health Sciences, and the University of Iowa conducted a national agricultural health study. Pesticide use and heredity may work together to increase farmers' risk of developing prostate cancer. Research established that the rate of prostate cancer is higher than normal among farmers, even though they generally surfer from lower rates of other types of cancer. The study found that people exposed to high levels of methyl bromide were "more likely to develop prostate cancer" (Chemical Market Reporter, 2002b).

Researchers studied the dynamics of mixed clusters of hydrogen bromide (HBr) and water and found that there was complete dissolution when HBr was surrounded by five water molecules. The team's detailed picture of how HBr dissolves in water could prove useful in atmospheric and biological chemistry (Chemical & Engineering News, 2002).

Outlook

Demand for flame retardants can fluctuate along with overall cycles in the economy. The economic slowdown, which began in 2000, had a significant adverse effect on flame retardant demand in 2002. Polymer chemical markets were weak across the board. Compounding the difficulties was a large inventory correction in the electronics industry (Chemical Products Synopsis, 2001).

Fire Retardants.—Bromine is a flame retardant and also acts in synergy with many other fire-retardant materials to increase the overall effectiveness of the fire retardant. Environmental and health concerns may reduce the long-term growth potential for halogenated flame retardants in general; however, growth in tetrabromobisphenol-A (TBBA) and certain other products is expected to replace some of the reduction.

Petroleum.—Demand for bromine as a gasoline additive has declined each year since the EPA issued regulations in the 1970s to reduce and eliminate lead in automotive gasoline. In 1979, the amount of bromine sold for this application reached a peak of 225 Mkg. The rapid decline to 141 Mkg in 1986 was a direct result of the limits on lead in leaded automotive gasoline. The CAA requires mobile sources, such as cars and trucks, to use the most effective technology possible to control emissions. Newer prototypes of the fuel cell that burn gasoline can double the mileage and thereby decrease emissions by using unleaded gasoline or other nonbrominated fuels. Use of calcium-, sodium-, and zinc-bromides in oil well completion fluids has benefited in recent years from the rebound in world oil prices and increased demand for petroleum products.

Sanitary Preparations.—Growth potential remains high for bromine-based biocides for use in industrial cooling systems because of environmental restrictions on chlorine and new alkaline-based chemical treatment programs. The most common bromine compounds used in cooling water are 1-bromo-3-chloro-5,5-dimethylhydantoin and mixtures of sodium bromide with sodium hypochlorous acid. Bromine was used in indoor swimming pools, hot tubs, and whirlpools. The sanitary preparation field is an area where bromine was found to be safer than its substitutes because bromine has a higher biocidal activity level for the same volume of product.

Other Uses.—Use of calcium-, sodium-, and zinc-bromides in well-completion fluids decreased during the 1980s because the domestic petroleum industry suffered a recession. In 2002, the oil-services sector posted a strong performance. About 95% of calcium bromide produced was used as an oil and gas completion fluid. Oilfield chemicals used in drilling, completion and workover, and production operations remained significantly more profitable internationally than in the United States. Use of calcium, sodium, and zinc bromides in oil-well-completion fluids has benefited in recent years from the rebound in world oil prices.

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TABLE 1

SALIENT BROMINE AND BROMINE COMPOUNDS STATISTICS[1]

(Thousand kilograms and thousand dollars)

	HTSUS[2] number	1998	1999	2000	2001	2002
United States:						
Bromine sold or used:[3]						
Quantity		230,000	239,000	228,000	212,000	222,000
Value		$162,000	$213,000	$206,000	$159,000	$166,000
Exports:[4, 5]						
Elemental bromine:	2801.30.2000					
Quantity		1,490	2,110	1,870	3,710	6,070
Value		$3,440	$2,430	$2,560	$3,600	$4,680
Bromine compounds:[6]	(7)					
Gross weight		10,200	9,520	9,210	7,990	8,000
Contained bromine		8,550	8,020	7,740	6,740	6,750
Value		$18,000	$16,000	$26,200	$14,900	$13,600
Imports:[4, 8]						
Elemental bromine:	2801.30.2000					
Quantity		1,200	1,970	5,470	5,610	2,020
Value		$1,060	$2,110	$3,730	$4,240	$1,530
Bromine compounds:						
Ammonium bromide:	2827.59.2500					
Gross weight		471 [9]	1,510 [9]	48,100	59,700	16,900
Contained bromine		384	1,240	3,930	4,870	1,380
Value		$1,280 [e]	$1,940	$22,000	$29,200	$8,850
Calcium bromide:	2827.59.2500					
Gross weight[9]		350	--	7,860	5,880	164
Contained bromine		280	--	6,280	4,700	131
Value		$213 [e]	--	$4,780 [e]	$3,580 [e]	$100 [e]
Potassium bromate:	2829.90.0500					
Gross weight		141	373	245	124	126 [9]
Contained bromine		67	178	117	59	36
Value		$571	$1,470	$1,100	$450	$457 [e]
Potassium bromide:[10]	2827.51.0000					
Gross weight		910 [9]	1,170	871 [9]	433 [9]	171 [9]
Contained bromine		611	786	585	291	115
Value		$2,220 [e]	$2,830 [e]	$2,130	$1,060 [e]	$417 [e]
Sodium bromate:	2829.90.2500					
Gross weight		1,100	1,050	1,160	1,020	1,020
Contained bromine		584	554	615	538	539
Value		$2,900	$2,430 [e]	$2,750	$2,190	$2,020
Sodium bromide:[10]	2827.51.0000					
Gross weight[9]		3,960	4,640	3,130	NA	2,980 [9]
Contained bromine		3,070	3,600	2,430	NA	2,320
Value		$6,090 [e]	$5,540 [e]	$4,820 [e]	NA	$4,600 [e]
Other compounds:						
Gross weight		8,990	7,400	7,760	5,950 [r]	4,920
Contained bromine		6,770	785	582	141	176
Value		$18,900	$17,000	$15,500	$5,360	$6,090
World, production[e]		521,000	547,000	542,000 [r]	523,000 [r]	543,000

[e]Estimated. [r]Revised. NA Not available. -- Zero.

[1]Data are rounded to no more than three significant digits. Revised as of March 2, 2004.

[2]Harmonized Tariff Schedule of the United States.

[3]Elemental bromine sold as such to nonproducers, including exports, or used by primary U.S. producers in preparing bromine compounds.

[4]Source: U.S. Census Bureau.

[5]Export values are free alongside ship.

[6]Source: U.S. Census Bureau. Includes methyl bromine and ethylene dibromide.

[7]Data for these compounds are derived from HTSUS numbers 2903.30.0500 (2001 and 2002), 2903.30.1500 (1998 and 1999), and 2903.30.1520 (2000 and 2002) information.

[8]Import values are cost, insurance, and freight.

[9]The Journal of Commerce Port Import/Export Reporting Service.

[10]"Bromides of sodium" or of "potassium" import data are usually reported by a mutual HTSUS number, 2827.51.0000.

TABLE 2
ELEMENTAL BROMINE-PRODUCING PLANTS IN THE UNITED STATES IN 2002

State and company	County	Plant	Production source	Capacity[1] (million kilograms)
Arkansas:				
Albemarle Corp.	Columbia	Magnolia (a)	Well brines	
Do.	do.	Magnolia (b)	do.	123 [2]
Great Lakes Chemical Corp.	Union	El Dorado (a)	do.	
Do.	do.	El Dorado (b)	do.	71 [2]
Do.	do.	Maryville	do.	36
Do.	do.	Newell	do.	23
Michigan, The Dow Chemical Co.	Mason	Ludington[3]	do.	9
Total				261

[1]Actual production capacity is limited by brine availability.
[2]This represents the cumulative capacity of the two identified plant sites.
[3]Bromine produced at this plant is reprocessed in Arkansas.

TABLE 3

U.S. IMPORTS OF OTHER BROMINE COMPOUNDS[1, 2]

Compounds	HTSUS[3] number	2001 Gross weight (kilograms)	2001 Value[4] (thousands)	2002 Gross weight (kilograms)	2002 Value[4] (thousands)	Principal sources, 2002
Hydrobromic acid	2811.19.3000	410	$362	360	$278	Israel, 97%; Canada, 3%.
Ethylene dibromide	2903.30.0500	448	446	(5)	10	Belgium, 57%; Japan, 42%; and Switzerland, 1%.
Methyl bromide	2903.30.1520	610	1,620	430	1,440	Israel, 100%.
Dibromoneopentyl glycol	2905.50.3000	1,320	4,330	1,010	3,350	Israel, 99%; Belgium 1%.
Tetrabromobisphenol A	2908.10.2500	1,130	1,700	832	1,210	Israel, 93%; Japan, 6%; and China, 1%.
Decabromodiphenyl oxide and octabromodiphenyl oxide	2909.30.0700	2,040	4,600	2,290	4,320	Israel, 99%; China, 1%.
Total		5,950	13,100	4,920	10,600	

[1]These data detail the information included in table 1, imports of "Other bromine compounds."

[2]Data are rounded to no more than three significant digits; may not add to totals shown.

[3]Harmonized Tariff Schedule of the United States.

[4]Declared cost, insurance, and freight valuation.

[5]Less than 1/2 unit.

Source: U.S. Census Bureau.

TABLE 4

WORLD BROMINE ANNUAL PLANT CAPACITIES AND SOURCES AS OF DECEMBER 31, 2002[1]

Country and company or plant	Location	Capacity (thousand kilograms)	Source
Azerbaijan, Neftechala Bromine Plant	Baku	4,000	Underground brines.
China, Laizhou Bromine Works	Shandong	30,000	Do.
France:			
Atochem	Port-de-Bouc	12,000	Seawater.
Mines de Potasse d'Alsace S.A.	Mulhouse	2,300	Bitterns of mined potash.
India:			
Hindustan Salts Ltd.	Jaipur		Seawater bitterns from salt production.
Mettur Chemicals Ltd.	Mettur Dam	1,500	
Tata Chemicals Ltd.	Mithapur		
Israel, Dead Sea Bromine Co. Ltd.	Sdom	190,000	Bitterns of potash production from surface brines.
Italy, Societa Azionaria Industrial Bromo Italiana	Margherita di Savoia	900	Seawater bitterns from salt production.
Japan, Toyo Soda Manufacturing Co. Ltd.	Tokuyama	20,000	Seawater.
Spain, Derivados del Etilo S.A.	Villaricos	900	Do.
Turkmenistan:			
Nebitag Iodine Plant	Vyshka	3,200	Underground mines.
Cheicken Chemical Plant	Balkan	6,400	Do.
Ukraine, Perekopskry Bromine Plant	Krasnoperckopsk	3,000	Do.
United Kingdom, Associated Octel Co. Ltd.	Amlwch	30,000	Seawater.

[1]Excludes U.S. production capacity which is detailed in table 2.

TABLE 5

BROMINE: ESTIMATED WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Thousand kilograms)

Country[3]	1998	1999	2000	2001	2002
Azerbaijan	2,000	2,000	2,000	2,000	2,000
China	40,000	42,000	42,000	40,000	42,000
France	1,950 [4]	1,950	2,000	2,000	2,000
Germany	600	500	500	500	500
India	1,500	1,500	1,500	1,500	1,500
Israel	185,200 [4]	181,000 [4]	210,000 [4]	206,000	206,000
Italy	300	300	300	300	300
Japan	20,000	20,000	20,000	20,000	20,000
Jordan	-- [4]	-- [4]	-- [4]	-- [4]	8,000
Spain	100	100	100	100	100
Turkmenistan	150	150	150	150	150
Ukraine	3,000	3,000	3,000	3,000	3,000
United Kingdom	35,900 [4]	55,000 [4]	32,000 [r, 4]	35,000 [r, 4]	35,000
United States[4, 5]	230,000	239,000	228,000	212,000	222,000
Total	521,000	547,000	542,000 [r]	523,000 [r]	543,000

[r]Revised. -- Zero.

[1]World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2]Table includes data available through April 18, 2003.

[3]In addition to the countries listed, several other nations produce bromine, but output data are not reported; available general information is inadequate to formulate reliable estimates of output levels.

[4]Reported figure.

[5]Sold or used by producers.